CHAPTER 6

LUBE OIL SYSTEMS

6-1. Lube oil system design features

A general facility lube oil system serving a diesel engine is shown on figure 6-1. As shown, a system may consist of storage tanks, interconnecting piping and piping components, instrumentation and controls, filtration equipment (strainers and filters), pumps, conditioning equipment (centrifuge), heaters, and heat exchangers.

a. Central lube oil storage and dispensing system. A central lube oil storage and dispensing system may consist of a clean lube oil receiving, storage, and supply system, and a dirty lube oil return and storage system. Where the facility is large, the system may also include intermediate storage tanks located at the points of lube oil use. A central lube oil storage and dispensing system with intermediate storage tanks is shown on figure 6-2. It is sometimes possible to remove the contaminants from dirty lube oil and recycle the cleaned lube oil to the clean oil system for reuse. A typical lube oil purification system is shown on figure 6-3.

(1) Clean lube oil may be received in bulk shipment. The bulk delivery unit may be equipped with a self-contained pumping unit, or an external pump which is part of the facility lube oil system (figure 6-2) may be required. In either case, facilities should have a strainer unit installed in the main lube oil tank fill line to minimize particulates entering the lube oil distribution system. The clean lube oil tank may also receive clean lube oil from intermediate storage tank overflows.

(a) The main clean lube oil tank may be equipped with some type of level gauge. The gauge may only have local readout capabilities, or a transmitter element may be part of the gauge so that the level in the tank can be monitored from a remote location. The tank may also be equipped with a level switch that activates an alarm when the lube oil level in the tank exceeds a preset level and is in danger of overflowing. This level switch may also be interlocked with the tank fill pump to turn the pump off, or may close a valve in the fill line. Depending on local climate, lube oil tanks installed outdoors or in unheated spaces may be equipped with a tank heater.

(b) A clean oil supply pump distributes the clean lube oil to end use points (figure 6-1) or, in large facilities, distributes the clean lube oil to intermediate storage facilities (figure 6-2). Typically, the clean oil supply pump operates only as needed. In many facilities, this allows clean lube oil supply and dirty lube oil disposal or centrifuge feed piping to be interconnected so that one pump system serves as the clean oil supply pump, the dirty oil disposal pump, and the lube oil purification system feed pump.

(c) Intermediate storage tanks (figure 6-2) may be used in large facilities to place a supply of lube oil close to an operation within the larger facility and allow that operation to supply individual user points within the operation from the intermediate tank. The intermediate tanks may be equipped with the same types of gauges, level switches, and control devices as the main storage tanks. Clean lube oil may be delivered by gravity or, as shown on figure 6-1, by a pump to a manual dispensing point or to the makeup lube oil connection on a piece of equipment.

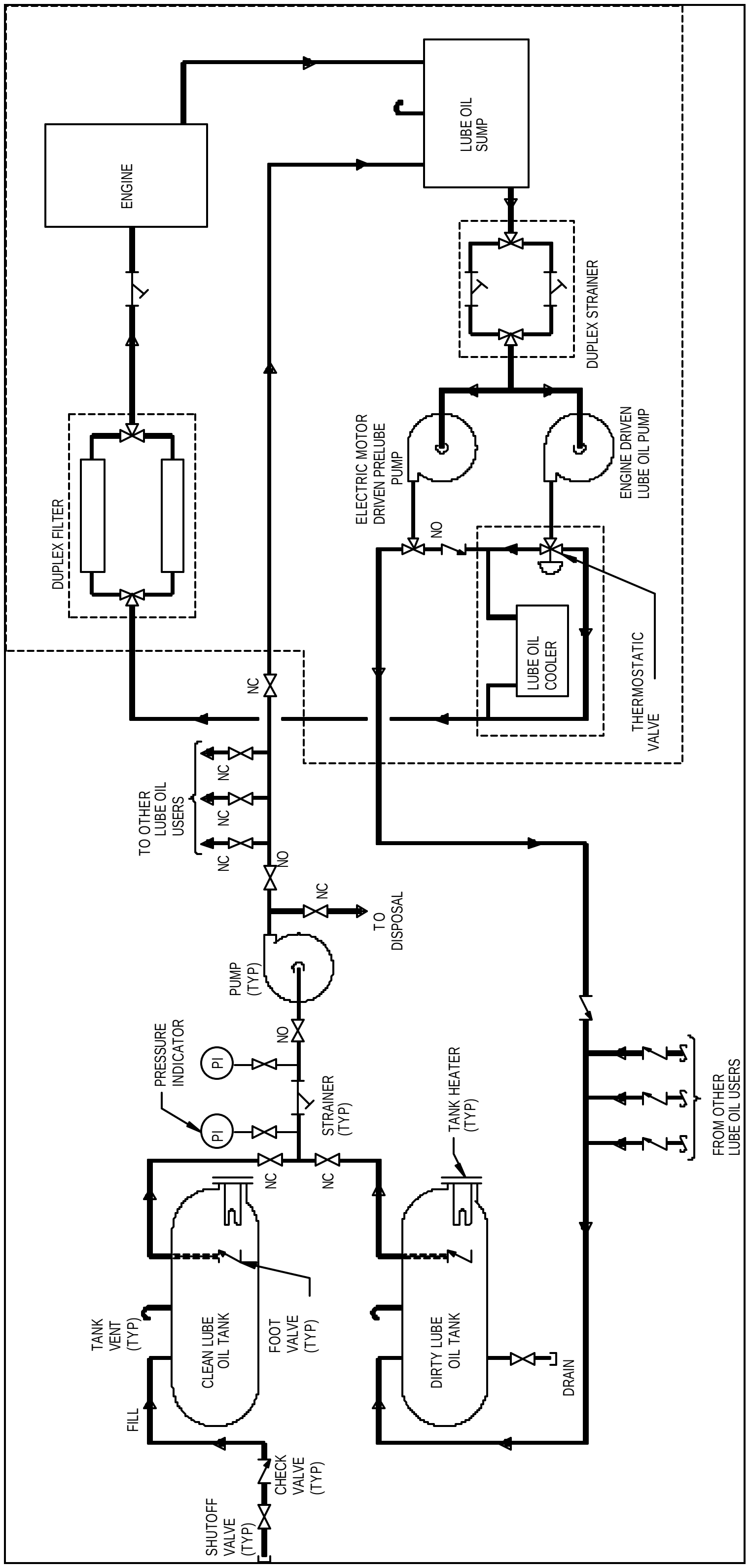

Figure 6-1. General lube oil system – diesel engine

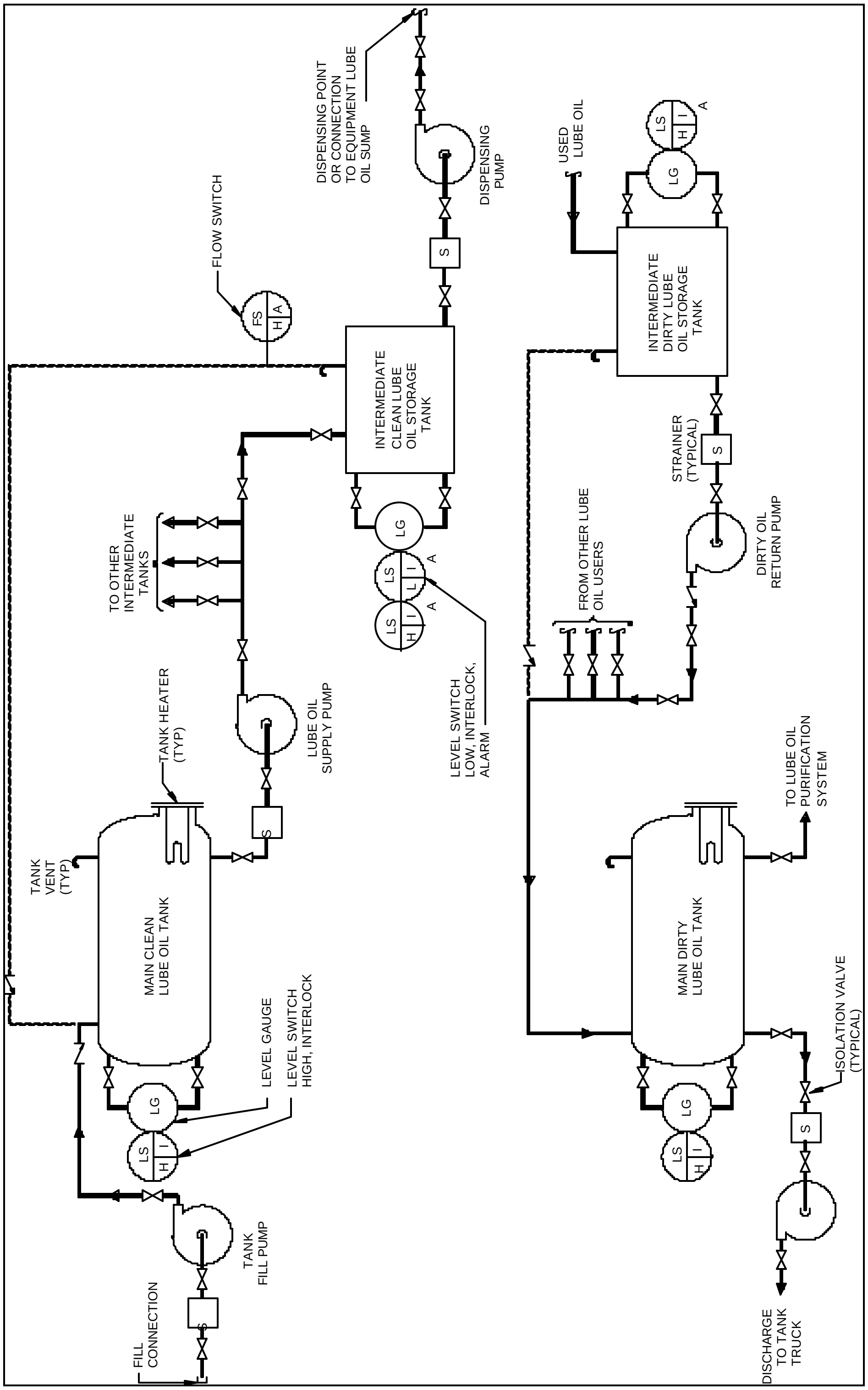

Figure 6-2. General lube oil storage and dispensing system

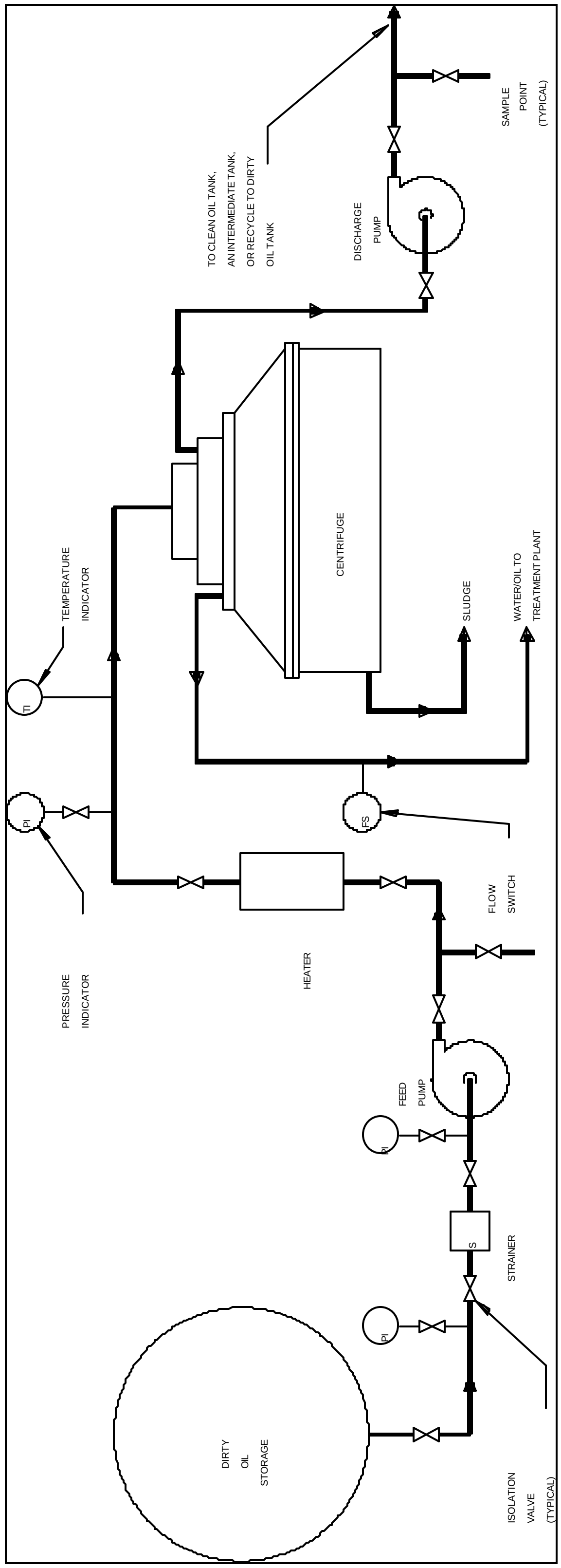

Figure 6-3. Lube oil purification system

(2) When the lube oil in a piece of equipment must be changed, the dirty lube oil may be returned to a main dirty lube oil tank. Depending on the size of the facility, there may be an intermediate dirty oil storage tank and a dirty oil return pump, as shown on figure 6-2. The dirty lube oil system may have many of the same type of devices and controls that were discussed as part of the clean lube oil system. For final disposal of dirty lube oil, the dirty lube oil tank will be equipped with a discharge. Depending on the tank location, oil may be discharged by gravity or by pumping. Final disposal may be delivery to a facility waste oil tank or to a waste disposal company, or oil recycling company tank truck or railroad tank car. Another discharge connection from the main dirty lube oil tank may be to a lube oil purification unit.

(3) Some dirty lube oil may be cleaned (purified) and reused as clean lube oil. Some lube oil users dirty the lube oil with contaminants that can be easily removed with commercially available centrifugal separation equipment. A typical centrifuge operation is shown on figure 6-3. Chemical analysis of the dirty lube oil determines whether the dirty lube oil can be cleaned and reused or is ready for final disposal.

b. Diesel engine lube oil system. Each diesel engine is equipped with a lubrication system that lubricates and cools various engine components when an engine operates. Depending on the service and size of the diesel engine, the lube oil system components may be part of the engine package and engine-mounted or mounted on the engine skid (typical of emergency service diesel engines), or may be stand-alone components (typical of large primary service diesel engines). The lube oil system components for diesel engines in either primary or emergency service generally have the same components and operate in a similar manner. A typical emergency service diesel engine lube oil system is shown on figure 6-4. A typical primary service diesel engine lube oil system is shown on figure 6-5.

(1) Monitoring and control of an engine lube oil system is by means of various pressure, temperature, and level monitoring gauges, instruments, and control valves. Typical diesel engine lube oil controls are shown on figures 6-4 and 6-5. Many of the instruments include switches that may prevent the engine from starting if the lube oil pressure, temperature, or flow does not meet some minimum requirement. They also may sound an alarm or shut the engine down if the oil pressure is too low, the oil temperature is too high, or the pressure drop across a filter is too high.

(2) Many diesel engines will have a lube oil heating system to maintain the lube oil near the normal lube oil temperature when the primary service diesel engine is in standby operation. The lube oil heating system may consist of a strainer, a circulating pump, and a heater. A typical primary service diesel engine standby operation lube oil heating system is shown on figure 6-6.

(3) The electric motor-driven prelube pump in an emergency service diesel engine lube oil system generally operates all the time when the diesel engine is not operating, but is in ready-to-operate standby service.

(4) The electric motor-driven prelube pump on a primary service diesel engine generally only operates for a short period of time before the diesel engine is started. Some older primary service diesel engines have hand-operated prelube pumps. Before starting an engine, the operator must use the hand-operated pump to pressurize the lube oil system. The prelube pump on primary service diesel engines may also be operated for a period of time when the engine is shut down to provide for controlled cooling of engine components.

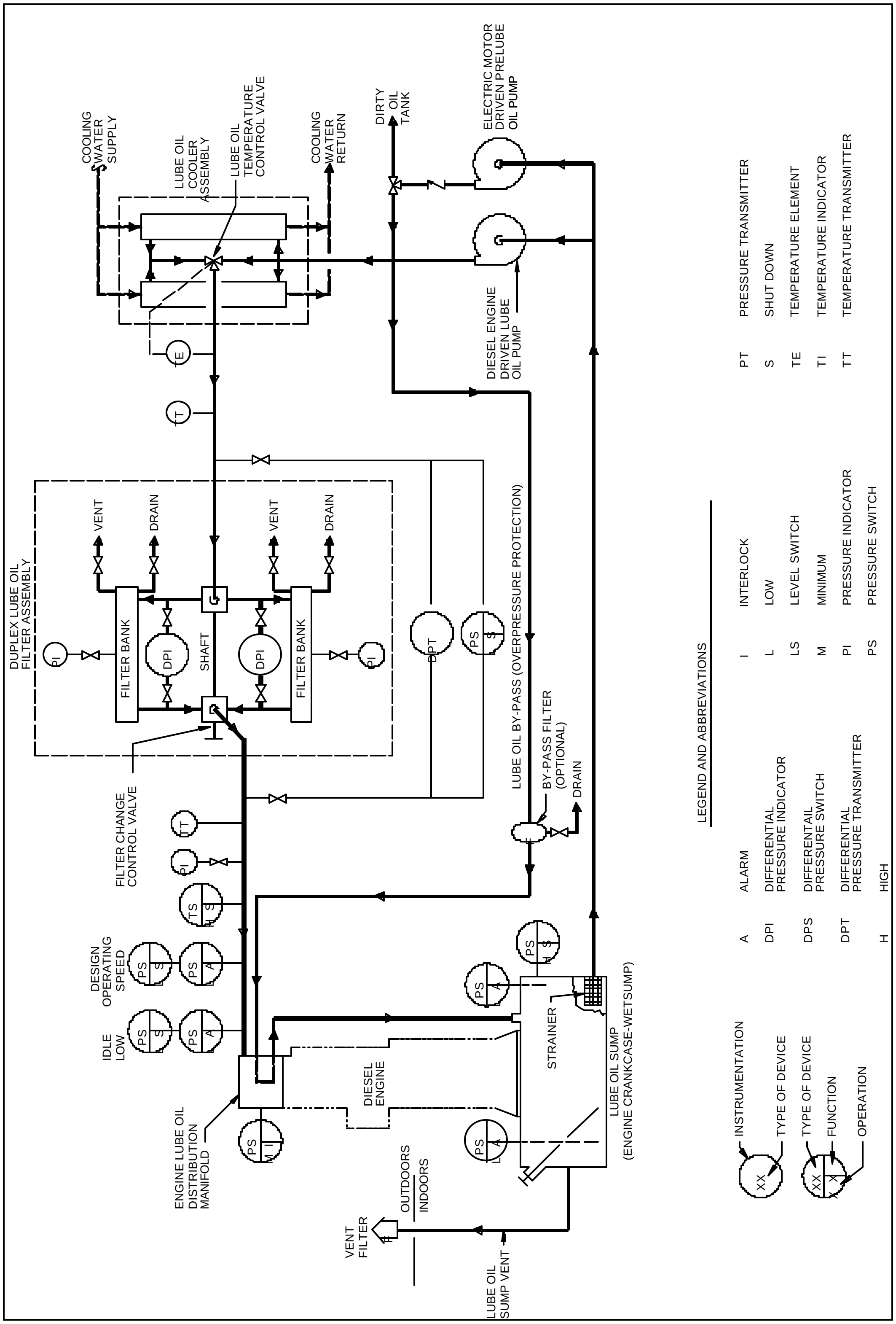

Figure 6-4. Emergency service diesel engine lube oil system

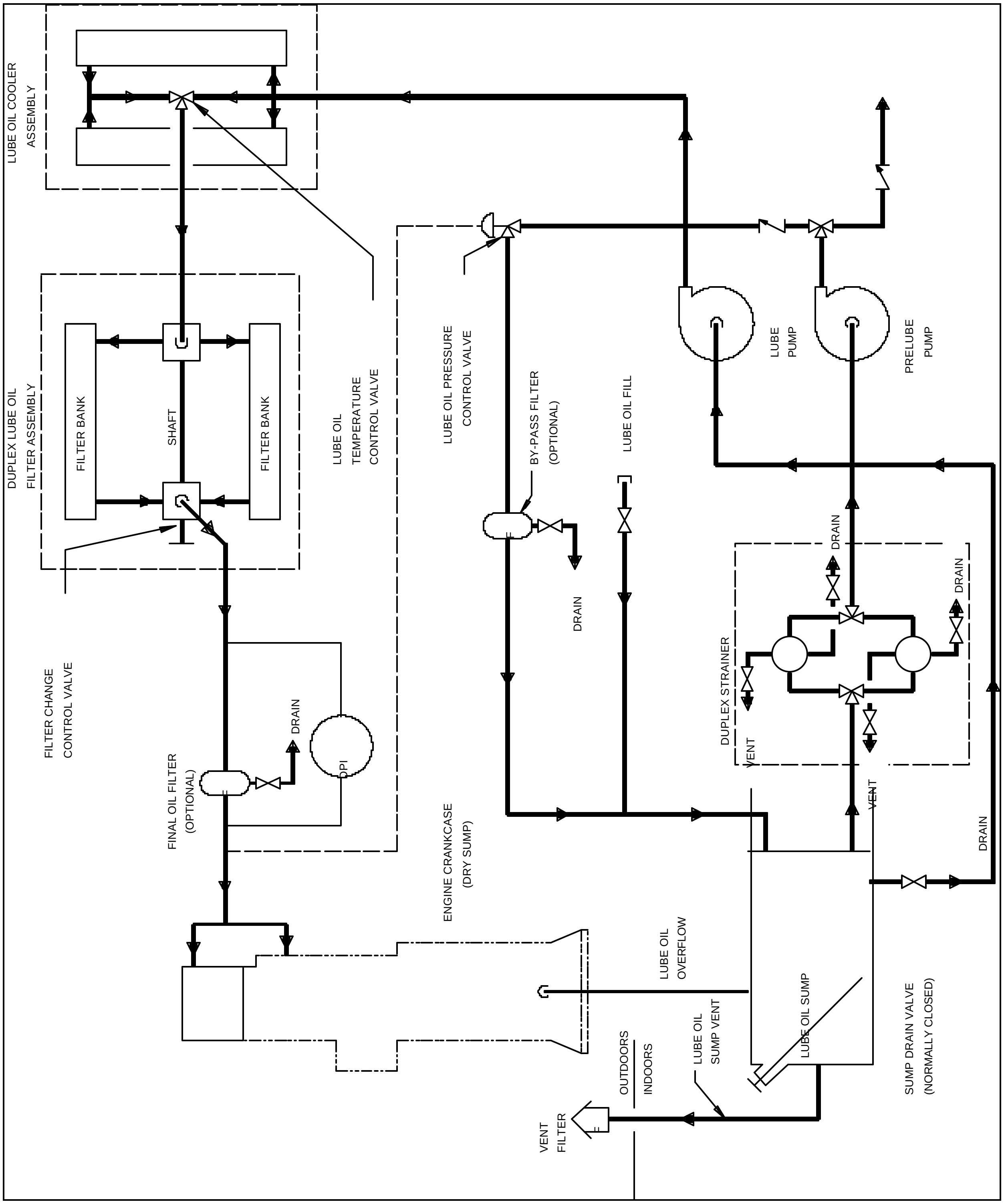

Figure 6-5. Primary service diesel engine lube oil system

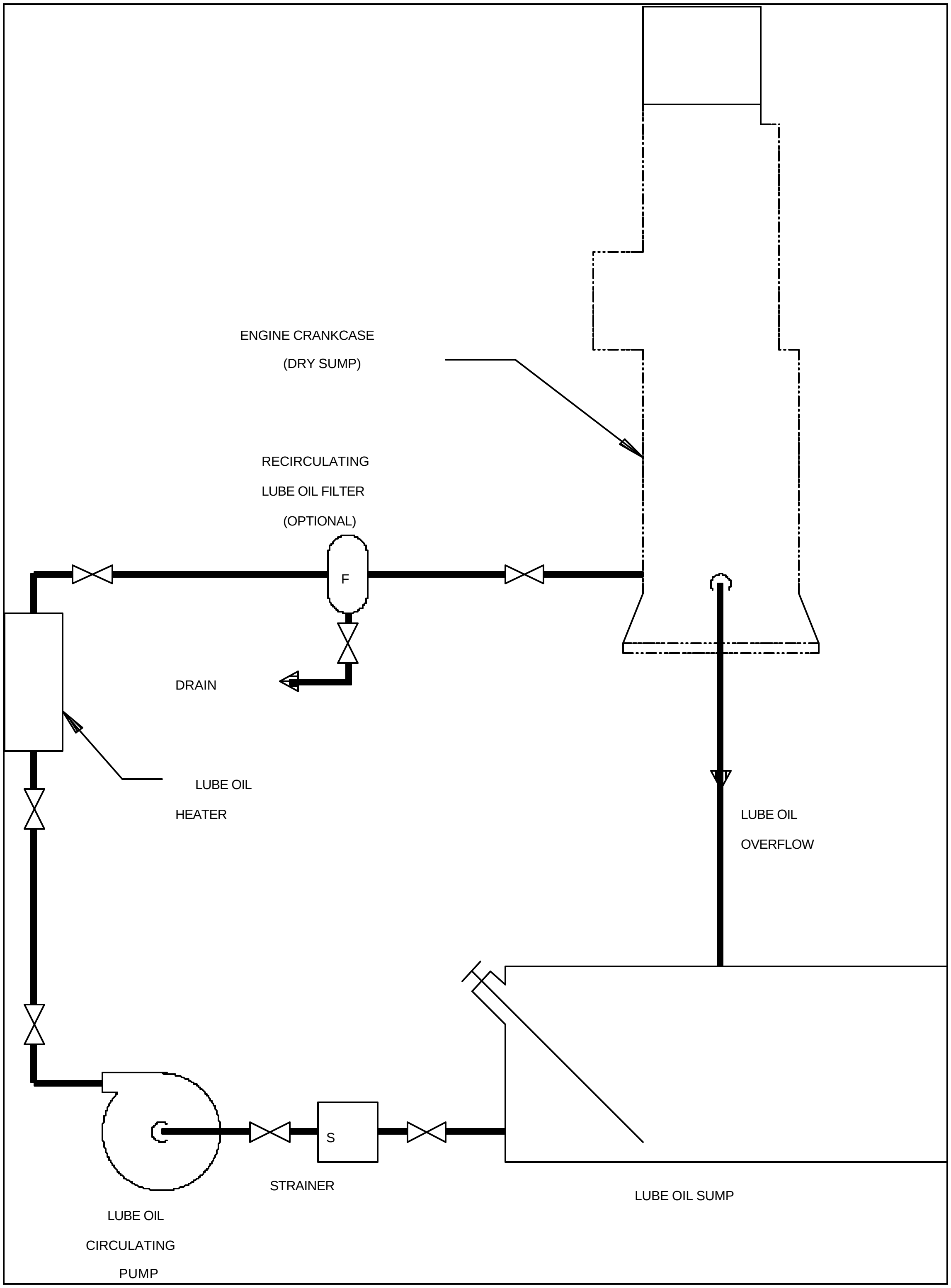

Figure 6-6. Diesel engine standby operation lube oil heating system

6-2. Lube oil system major components

The lube oil system is comprised of the following major components.

a. Pumps. Various types of pumps are utilized in lube oil systems.

(1) For a discussion of the types of pumps which may be used in lube oil systems for transferring lube oil throughout the facility, see chapter 5.

(2) The engine oil pump pulls oil from the lube oil sump and is the pressure pump supplying lubricant to the engine when the engine is operating. The main lube oil pump is usually mounted on the engine and is a positive displacement pump, gear-driven by the engine.

(3) The prelube pump is generally a close-coupled, self-priming, positive displacement pump of the rotary lobe or gear type. The prelube pump is driven by an electric motor. The prelube pump pulls oil from the lube oil sump and supplies lubricant to the engine when the engine is in standby operation.

b. Storage tanks. Storage tanks are generally fabricated from carbon steel plate with welded joints. All lube oil tanks should be fabricated and operated in accordance with the general requirements of National Fire Protection Association (NFPA) 30, Flammable and Combustible Liquids Code (1996), for flammable liquid storage. Most lube oil is stored in atmospheric storage tanks. Most storage atmospheric tanks are either the vertical or horizontal cylindrical type.

c. Heat exchangers. Heat exchangers are commonly used in both the lube oil cooler and lube oil heating subsystems.

(1) The lube oil cooler assembly generally uses shell-and-tube heat exchangers. Depending on the lube oil flow rate, a single heat exchanger may be used or two or more units may be used. When more than one heat exchanger unit is required, it is common to connect the heat exchangers in parallel. Lube oil is generally piped through the shell (outside the tubes), and the cooling fluid is piped through the tubes (inside the tubes). Some newer facilities may use, or may have replaced old shell-and-tube units with, plate type heat exchangers.

(2) The heat source may be steam (preferred for high capacity heating), hot oil, hot water, or low density electric (low flow applications) depending on the needs of other operations at the facility.

(a) Lube oil storage tank heaters are generally of the convection type. The tank heater should be designed for insertion into the storage tank through a manhole that does not exceed 24 inches diameter. Convection type heaters should have the capacity to raise the temperature of a full tank of lube oil by about 60°F in 24 hours.

(b) Lube oil in-line heaters are generally of the shell-and-tube type for liquid-to-liquid heat transfer or the electric bayonet type. For electric heaters, the heater should be designed so that the heating element can be removed without draining the heater shell.

d. Strainers. Strainers are used to remove coarse particulate matter that may damage rotating equipment.

e. Filters. Particulate filters are used to remove fine particulate from lube oils.

f. Centrifuge. The lube oil purification system centrifuge is utilized for purification (separation of liquids) and clarification (removal of solids). This unit is generally a high-speed centrifuge with a self-cleaning bowl. Centrifuge units are generally supplied as complete units. They include: differential pressure gauges; sight glass elements on the water discharge; a diaphragm-operated control valve in the main discharge with a flow-limiting pilot and a float-operated pilot to close the main valve if the water level in the sump rises above a set point; an automatic, float-controlled, diaphragm-operated water drain valve; a manual water drain valve; a head lifting device; and automatic air release devices.

g. Engine lube oil temperature control valves. Temperature control valves are used in engine cooling systems which use a lube oil bypass to maintain either a constant lube oil temperature at the engine lube oil outlet or a constant lube oil supply temperature. The most common engine lube oil temperature control valve is a self-contained, factory-set, thermostatic element-operated, sealed three-way valve unit. When installed to maintain a constant lube oil outlet temperature, the unit is referred to as a diverting valve. When installed to maintain a constant lube oil inlet temperature, the unit is referred to as a mixing valve. The valve is designed to maintain full lube oil flow through the engine cooling system. A thermostatic element in one of the valve ports controls a sliding valve assembly that controls the flow through that port. In the closed position, all of the flow is from the inlet port and out the other port. As the thermostatic element moves the sliding valve off the valve seat, a portion of the flow is from the inlet and through the thermostatically controlled port. At full lift, all of the flow is through the thermostatic port.

h. Valves and piping. This subsection presents an overview of the types of piping components and design and testing considerations related to facility lube oil distribution and dispensing piping systems. Information contained in this section applies to field-installed piping. Piping design, materials, fabrication, assembly, erection, inspection, and pressure tests for facility piping systems should be in accordance with American Society of Mechanical Engineers (ASME) 31.3, Process Piping. Inspection of modified piping installations should include radiographic or magnetic particle inspection of welds where applicable. New piping should also be hydrostatic tested. During testing, system components such as storage tanks, filters, centrifuges, or similar equipment that was not designed for the piping test pressure must be disconnected and protected against damage by overpressure.

(1) Valve bodies and bonnets should, as a minimum, be cast or forged carbon steel in accordance with American Society for Testing and Materials (ASTM) A 105, Standard Specification for Carbon Steel Forgings for Piping Applications (1998), for forged body valves and ASTM A 216, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service (1998), Grade WBC, for cast body valves. Cast iron or bronze body valves are not suitable for lube oil service. The typical types of valves and valve trims used in lube oil service are as follows.

(a) Gate valves may be used for lube oil shutoff service where a slow closure is acceptable and where absolute bubbletight closure is not a critical consideration. Gate valves may be rising stem, outside stem and yoke (OS&Y), or double-disk type.

(b) Ball, butterfly, or non-lubricated plug valves are generally used where quick or frequent opening or closing is required. Synthetic seals or seating material in ball and butterfly valves should be teflon or viton. Butterfly valves shall be high-performance type with eccentric disk shaft and camming action for bubbletight shutoff.

(c) Double-seated plug or ball valves with an automatic body bleed between the seats should be used for separation of product services on tank shell connections and other locations critical to pressure testing of piping.

(d) Check valves are used in the lube oil system to prevent backflow through pumps, branch lines, meters, or other locations where runback or reverse flow must be avoided. Check valves may be of the swing disk, spring-loaded poppet, ball, or diaphragm-actuated types. Swing checks should be a soft-seated, non-slamming type with renewable seats and disks.

(e) Globe valves are used in lube oil systems at locations where manually controlling the flow rate is required. General use of globe valves should be avoided because of their high resistance to flow.

(f) Diaphragm type valves typically operate on the basis of pressure differential and are used for automatic or remote control of functions, such as flow control, pressure control, or level control. All diaphragm type valves should have teflon or viton packing, seals, and trim.

(2) Pipe used in lube oil systems is generally, as a minimum, carbon steel conforming to the requirements of ASTM A 106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service (1999), Grade B, seamless for pipe 1-1/2 inches in diameter and smaller and ASTM A 53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless (1999), Grade B, ERW for pipe 2 inches in diameter and larger. Pipe 1-1/2 inches in diameter and smaller should be Schedule 80 in accordance with ASME B36.10M, Welded and Seamless Wrought Steel Pipe (1996), and pipe 2 inches in diameter and larger should be Schedule 40.